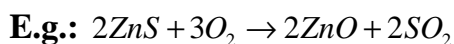


## GENERAL PRINCIPLES OF METALLURGY

### Short Answer Questions:

#### \*\*1. Giving examples to differentiate roasting and calcinations?

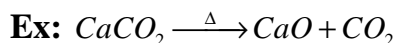
A: **I. Roasting:** The process of heating the mineral to high temperature in presence of air (or) oxygen is called roasting. During roasting the mineral gets oxidized.



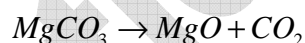
Different types of roasting are

a. oxidizing roasting    b. sulphatizing roasting    and    c. chloridizing roasting

**II. Calcination:** Removal of the volatile components of mineral by heating it strongly in the absence of air is called calcination. This method is generally applicable to carbonate and bicarbonate minerals to obtain their oxides



Lime stone                      lime



Magnesite                      Magnesium oxide

\*Both Roasting and calcination processes are carried in reverberatory furnace.

S. No.	Roasting	Calcination
1.	Ore is heated in the presence of excess of air or oxygen	Ore is heated in the absence or limited supply of air or O <sub>2</sub>
2.	This method is employed for sulphide ores.	This method is employed for carbonate ores.
3.	Sulphur dioxide is produced along with metal oxide	Carbon dioxide is produced along with metal oxide.
4.	e.g. $2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2 \uparrow$	e.g., $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2 \uparrow$

#### \*\*2. Explain the purification of sulphide ore by froth floatation method

A: **Froth Floatation Process:**

It is mainly used to concentrate low grade sulphide ores. This process is based on different wetting properties of gangue and the ore with water and oil.

In this process the ore is finely powdered. It is suspended in water taken in a tank. To it, collectors like pine oil or olive oil, frothing agent like sodium ethyl xanthate and froth stabilizers like cresol or aniline are added. Collectors enhance non-wet ability of the mineral particles and froth stabilisers stabilise the froth. A suitable pH is maintained in the solution by adding

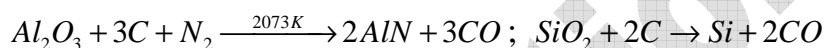
conditioners like lime or sodium carbonate. This makes the ore particles to float on water. The mineral particles become wet by oils while the gangue particles by water. A rotating paddle agitates the mixture and draws air in it. As a result froth is formed which carries the mineral particles. The froth is light and is skimmed off and then dried for recovery of the ore particles.

**Ex:** Copper pyrites, iron pyrites, zinc blende, galena etc are concentrated by this process.

**\*3. How is alumina separated from silica in the bauxite ore associated with silica? Give equations?**

**A:** Bauxite containing silica impurity is called white bauxite and is purified by Serpeck's process. In this process

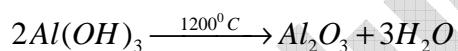
i. White bauxite is mixed with coke and heated to 2073K in the current of nitrogen gas to get aluminium nitride. Silicon dioxide is reduced to silicon and it escapes as a vapour.



ii. Aluminium nitride on hydrolysis gives  $Al(OH)_3$  precipitate



iii.  $Al(OH)_3$  is washed, dried and then ignited to get Pure aluminium oxide .

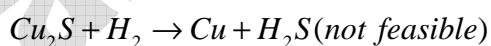
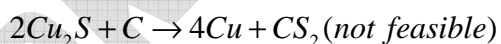


This alumina is subjected to electrolytic reduction to get aluminium

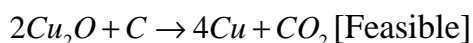
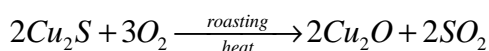
**4. Why is the extraction of copper from pyrites more difficult than that from its oxide ore through reduction?**

**A:** The standard free energy of formation ( $\Delta_f G^0$ ) of  $Cu_2S$  is greater than those of  $CS_2$  and  $H_2S$ .

thus  $Cu_2S$  (pyrites) cannot be reduced by carbon (or) hydrogen

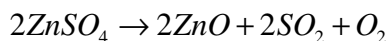
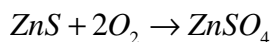
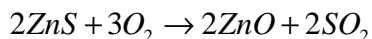


However the  $\Delta_f G^0$  of copper oxide is less than that of  $CO_2$ . Therefore, the sulphide ore is first converted to oxide by roasting and then reduced.

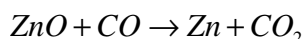
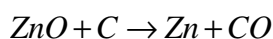


**5. Write down the chemical reactions taking place in the extraction of zinc from zinc blende.**

**A:** The concentrated ore is roasted in rotary shelf burner which is provided with horizontal shelves and raking arms. During roasting the following reactions take place



**Reduction:** Different methods are available for the reduction of zinc oxide to zinc. The most commonly used is 'Belgian process.'

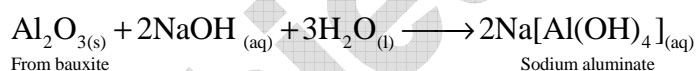


Some of the zinc metal is obtained in fused state which is solidified in moulds. This is called 'zinc spelter' and it contains some impurities such as cadmium and lead.

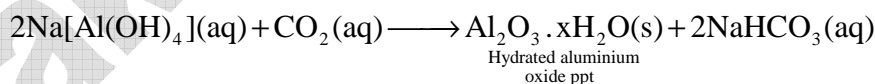
**\*6. Explain the process of leaching of alumina from bauxite?**

**A: Baeyer's process:** Bauxite ore is concentrated by the method of leaching or chemical separation.

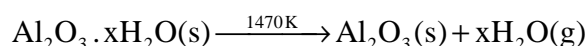
i. This method involves the digesting of powdered bauxite ore with concentrated NaOH at 473-573 K and 35-36 bar pressure.  $Al_2O_3$  is leached out as sodium aluminate leaving the impurities behind.



ii. Now  $CO_2$  gas is passed through the solution and a small amount of freshly prepared hydrated aluminium oxide is also added in order to induce the precipitation



iii. The impurities of silica remain in the solution and the precipitate formed is filtered, washed, dried and ignited to produce pure alumina

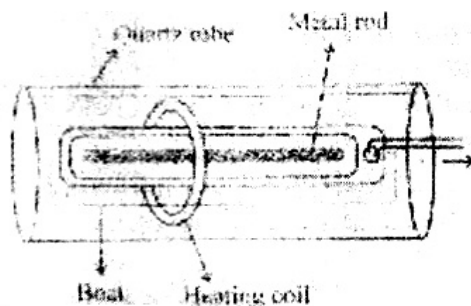


\*7. Outline the principles of refining of metals by the following methods:

- a) Zone refining
- b) Electrolytic Refining
- c) Poling
- d) Vapour Phase Refining

A: a) **Zone Refining:**

In this process highly pure metal is obtained. Impure metal is made into a rod and it is electrically heated till the metal in the heated zone melts. Heating coil is now slowly moved along the rod. The pure metal crystallizes out of the melt while impurities remain in the melt. The process is repeated until highly pure metal is obtained



b) **Electrolytic Refining:** Impure metal is made as anode and the pure metal is made as cathode. Molten (or) aqueous solution of metal salt is made as electrolyte. On passing electricity pure metal is deposited at cathode and impurities settle down below the anode as 'anode mud'

**E.g.:** Cu, Ag, Au etc, are purified by this method

c) **Poling:** This method is used when the metal contains metal oxide as impurity. Molten metal is covered with carbon powder and stirred with green wood logs (poles). The carbon and gases released from the green wood logs reduce the metal oxide to the metal

**E.g.:** Cu & Sn metals are refined by this method

d) **Vapour Phase Refining:** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. So the two requirements are

- i) The metal should form a volatile compound with an available reagent
- ii) The volatile compound should be easily decomposable, so that the recovery is easy

**8. Explain briefly the extraction of aluminium from bauxite?**

**Ans.** Aluminium is obtained by the electrolysis of fused anhydrous alumina at 1175 to 1225K.  $CaF_2$  is added to alumina to lower its melting point and cryolite is added to increase the conductivity of fused alumina

**Anode:** carbon rods

**Cathode:** rectangular iron tank lined with carbon

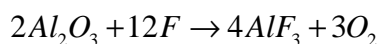
**Electrolyte:** mixture of pure alumina & cryolite

**Ionisation:**  $Na_3AlF_6 \rightarrow 3NaF + AlF_3$   
(cryolite)



**At cathode:**  $Al^{+3} + 3e^- \rightarrow Al$  (reduction)

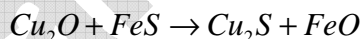
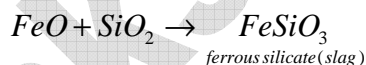
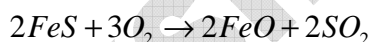
**At anode:**  $12F^- \rightarrow 12F + 12e^-$  (oxidation)



The  $O_2$  liberated attacks the carbon anodes to form  $CO$  &  $CO_2$  hence they are to be replaced.

**\*9. Explain smelting process in the extraction of copper?**

**Ans. Smelting:** The roasted ore is mixed a little coke and sand (silica) and smelted in a blast furnace and fused. A blast of air, necessary for the combustion of coke, is blown through the tuyeres present at the base of the furnace. The oxidation of the sulphides of copper and iron will be completed further. A slag of iron silicate is formed according to the reactions given below



**10. What is Ellingham diagram? What information can be known from this in the reduction of oxides?**

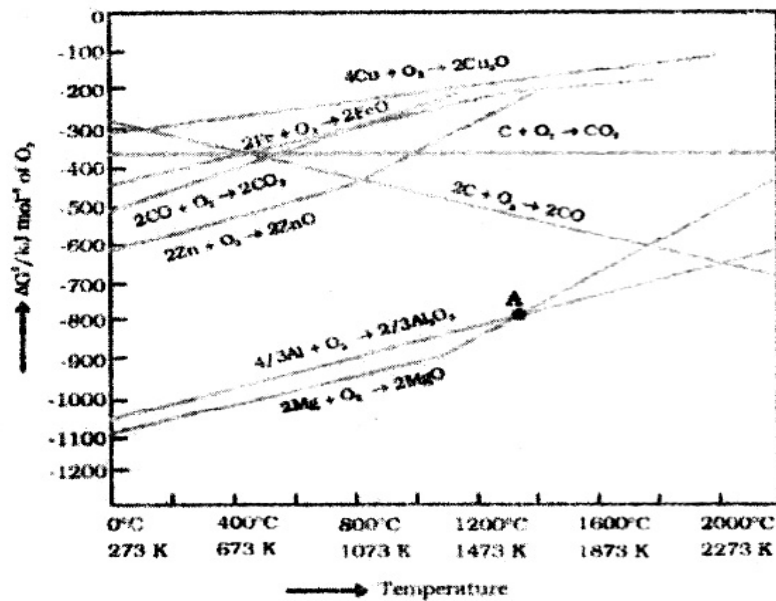
**Ans.** The graphical representation of Gibbs energy was first used by H.J.T Ellingham.

The diagram provides the choice of reducing agent in the reduction of oxides.

The diagram helps us in predicting the feasibility of thermal reduction of an ore.

If  $\Delta G$  is  $-ve$  the thermal reduction of an ore is feasible

Ellingham diagram normally consists of plots of  $\Delta G^0$  vs T for formation of oxides of elements i.e., for the reaction  $2xM_{(s)} + O_{2(s)} \rightarrow 2M_xO_{(s)}$



### Very Short Answer Questions

**1. What is the role of cryolite in the metallurgy of aluminium?**

**Ans.** In the metallurgy of aluminium, Cryolite ( $\text{Na}_3\text{AlF}_6$ ) is added to increase the conductivity and to lower the melting point of alumina ( $\text{Al}_2\text{O}_3$ ).

**2. What is the role of depressant in froth floatation process?**

**Ans.** In froth floatation process, depressant prevents the formation of froth. it is used to separate two sulphide ores by preventing the formation of froth of one sulphide ore and allowing the other to form the froth.

**E.g.,** NaCN is a depressant selectively prevents ZnS from coming in froth but allows PbS to come with the froth.

**3. Name the common elements present in the anode mud in electrolytic refining of copper?**

**Ans.** Metals which are less reactive and valuable like silver, gold, platinum etc., are found in anode mud.

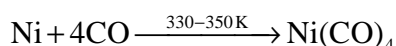
**4. State the role of silica in the metallurgy of copper?**

**Ans.** Silica acts as an acidic flux during the metallurgy of copper. It reacts with the impurities of iron and form slag. FeS is present in the form of impurity with copper sulphide ore.

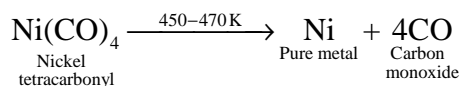


**5. Describe a method for refining nickel?**

**Ans. Mond's Process:** Nickel is heated in a stream of carbon monoxide forming a volatile complex, nickel tetra carbonyl.



Nickel tetra carbonyl on strong heating decomposes to give pure nickel metal.



**6. What is matte? Give its composition?**

**Ans.** The molten mixture obtained after smelting of copper pyrite ore in blast furnace is called as matte. It contains  $\text{Cu}_2\text{S}$  and  $\text{FeS}$ .

**7. What is blister copper? Why is it so called?**

**Ans.** The variety of copper obtained after bessemerisation of matte is called blister copper which is about 98% pure copper. It is so called because it has blistered appearance due to evolution of  $\text{SO}_2$  gas.

**8. What is flux? Give an example?**

**Ans.** The substance added to ore to lower the melting point of the impurities is known as flux. Flux combines with the gangue chemically and forms easily fusible product called slag.

**E.g.:**  $\text{SiO}_2$  is the acidic flux used to remove  $\text{FeO}$  impurity in copper extraction.

**9. Explain magnetic separation of impurities from an ore?**

**Ans.** The finely powdered ore is dropped on a belt moving on two rollers in which one is magnetic. As the mass passes over the electromagnetic roller, the non magnetic particles fall away directly while the magnetic particles fall into a separate heap.

For example, tin stone ( $\text{SnO}_2$ ), a non magnetic ore is separated from the magnetic impurity wolframite,  $\text{FeWO}_4$  by this method.

**10. How is aluminium useful in the extraction of chromium and manganese from their oxides?**

**Ans.** Aluminium is used as a reducing agent in the extraction of chromium and manganese from their oxides. It is known as aluminothermic process.

